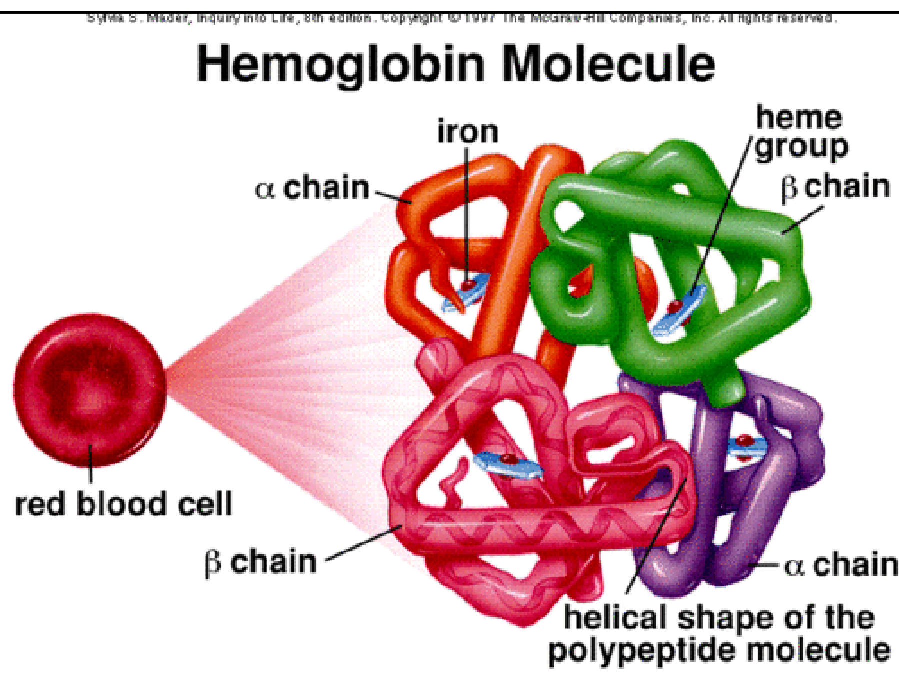
Big Idea 4 - Interactions

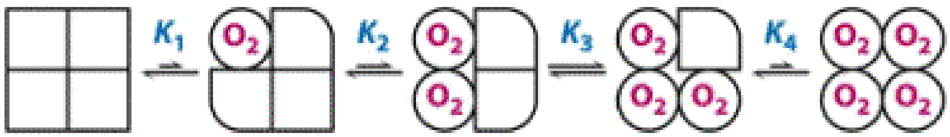
Part B – Competition & Cooperation are important aspects of biological systems

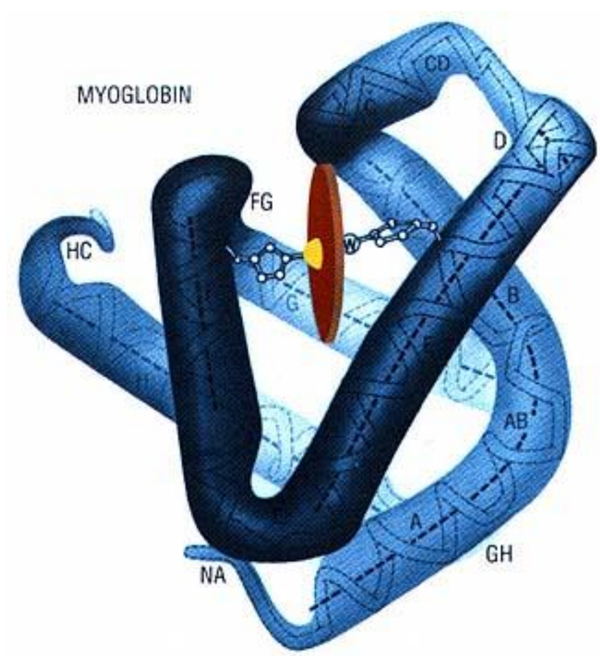
I. Models of Molecular Interactions

- Oxygen transport
- **Hemoglobin**
  - binds oxygen in a cooperative fashion
  - Transports & delivers O_2 to body tissues
  - Picks up CO_2 for disposal
- **Myoglobin** binds oxygen aggressively
  - Binds oxygen for use in **muscles**

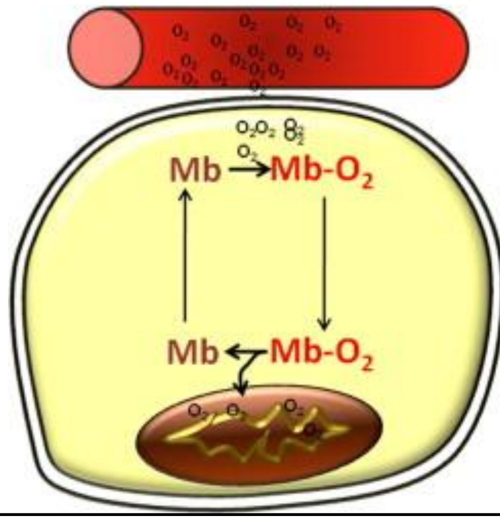


- Cooperativity
- Each oxygen bound increases affinity for more oxygen

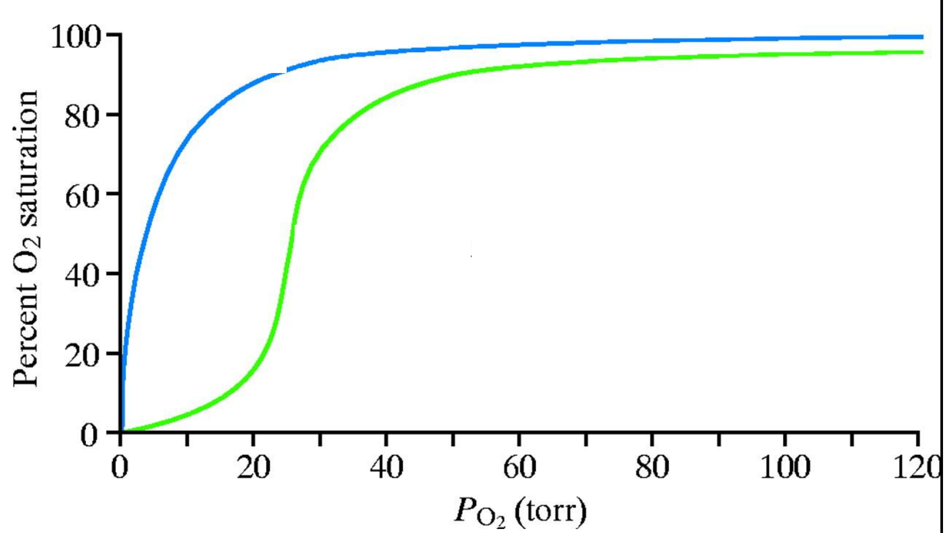




- Myoglobin binds 1 oxygen from blood
- What does this imply about its affinity requirements as compared to hemoglobin???



Hb vs. Mb



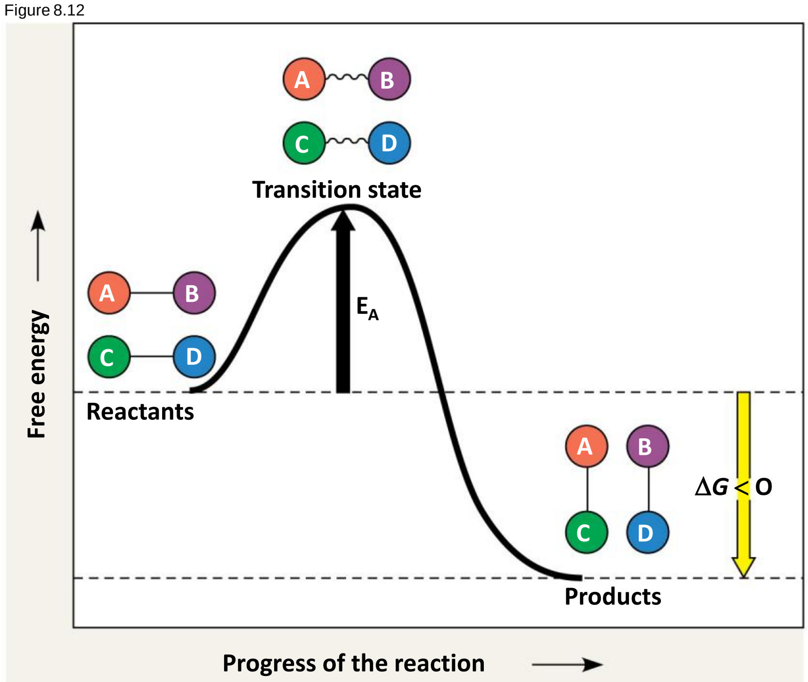
II. Enzymes

- Speed up metabolic reactions by lowering energy barriers
- A **catalyst** is a chemical agent that speeds up a reaction without being consumed by the reaction
- An **enzyme** is a catalytic protein

The Activation Energy Barrier

- Every chemical reaction between molecules involves bond breaking and bond forming
- The initial energy needed to start a chemical reaction is called the free energy of activation, or **activation energy (E_A)**
- Activation energy is often supplied in the form of thermal energy that the reactant molecules absorb from their surroundings

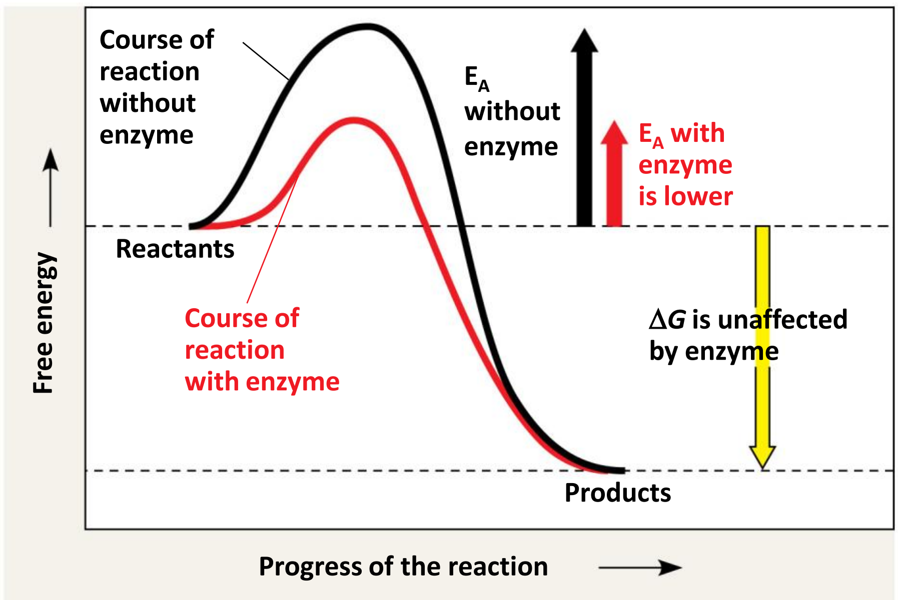
Figure 8.12



How Enzymes Lower the E_A Barrier

- Enzymes catalyze reactions by lowering the E_A barrier
- Enzymes do not affect the change in free energy (ΔG); instead, they hasten reactions that would occur eventually

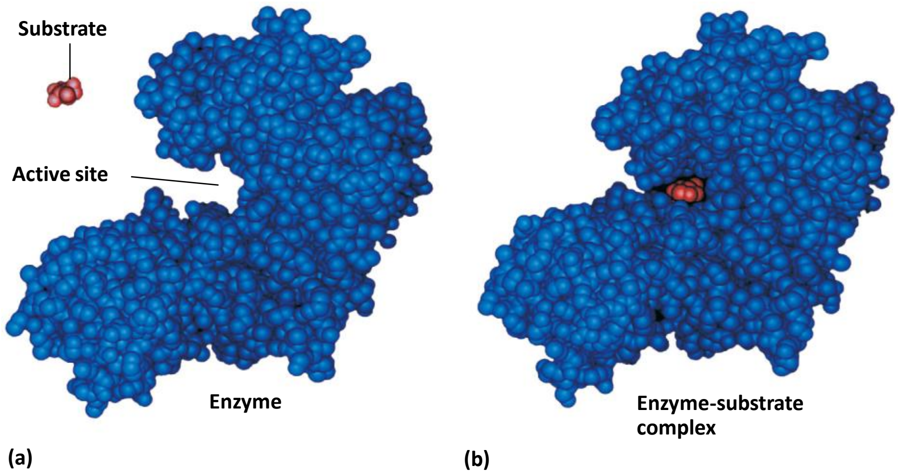
Figure 8.13



Substrate Specificity of Enzymes

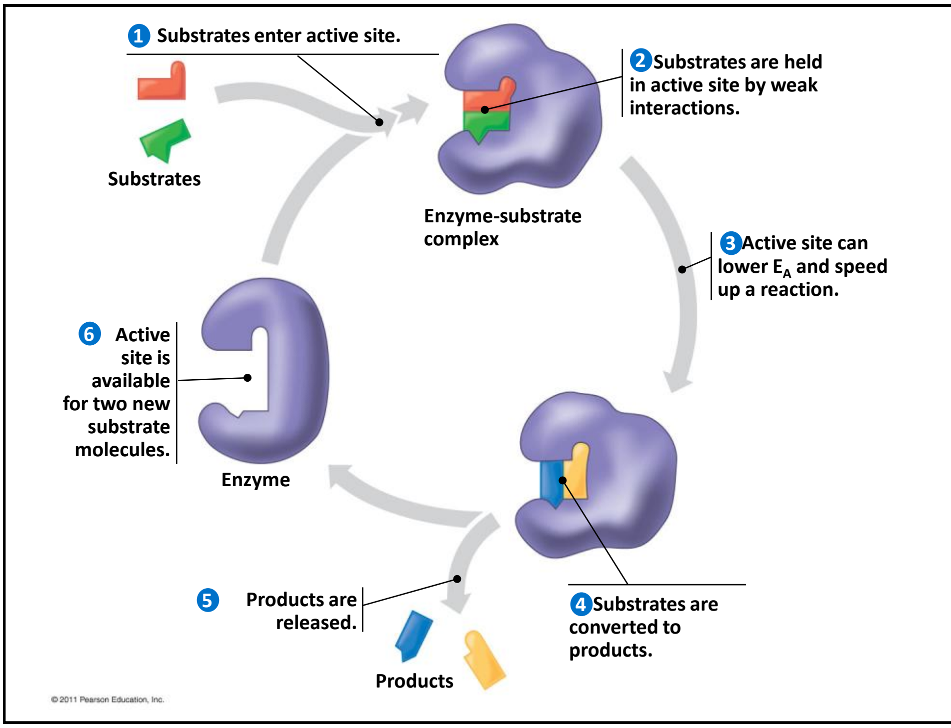
- The reactant that an enzyme acts on is called the enzyme's **substrate**
- The enzyme binds to its substrate, forming an **enzyme-substrate complex**
- The **active site** is the region on the enzyme where the substrate binds
- **Induced fit** of a substrate brings chemical groups of the active site into positions that enhance their ability to catalyze the reaction

Figure 8.14



Catalysis in the Enzyme's Active Site

- In an enzymatic reaction, the substrate binds to the active site of the enzyme
- The active site can lower an E_A barrier by
  - Orienting substrates correctly
  - Straining substrate bonds
  - Providing a favorable microenvironment
  - Covalently bonding to the substrate



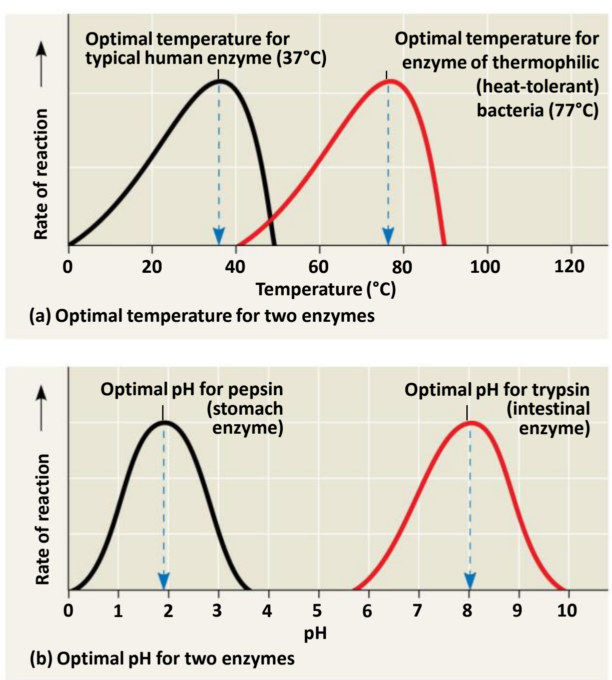
Effects of Local Conditions on Enzyme Activity

- An enzyme's activity can be affected by
  - General environmental factors, such as temperature and pH
  - Chemicals that specifically influence the enzyme

Effects of Temperature and pH

- **Each** enzyme has an optimal temperature in which it can function
  - WHY???
- **Each** enzyme has an optimal pH in which it can function
  - WHY???
- Optimal conditions favor the most active shape for the enzyme molecule

Figure 8.16



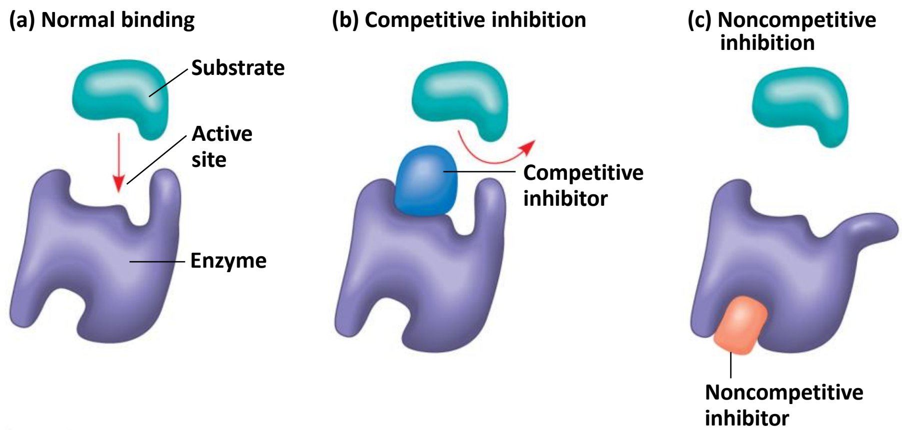
Cofactors

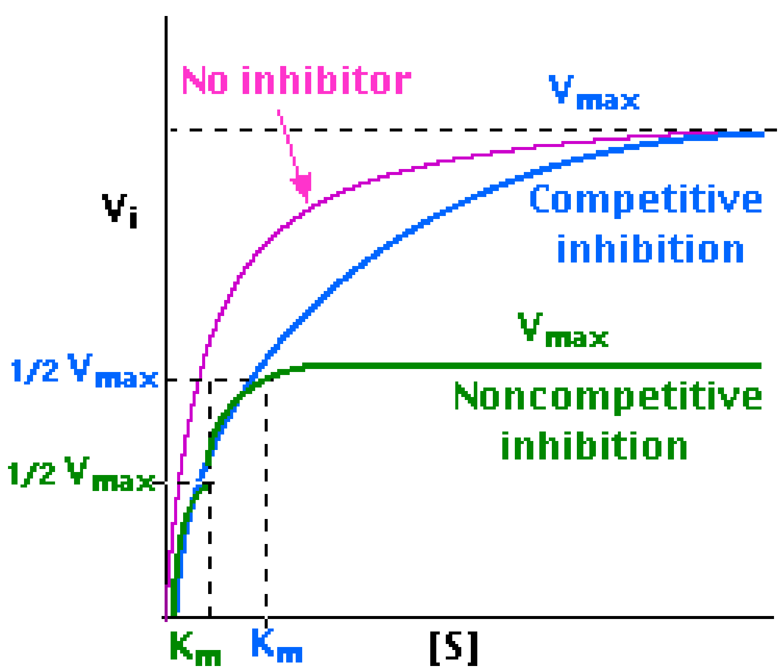
- **Cofactors** are nonprotein enzyme helpers
- Cofactors may be inorganic (such as a metal in ionic form) or organic
- An organic cofactor is called a **coenzyme**
- Coenzymes include vitamins

Enzyme Inhibitors

- **Competitive inhibitors** bind to the active site of an enzyme, competing with the substrate
- **Noncompetitive inhibitors** bind to another part of an enzyme, causing the enzyme to change shape and making the active site less effective
- Examples of inhibitors include toxins, poisons, pesticides, and antibiotics

Figure 8.17


(a) Normal binding
Substrate
Active site
Enzyme
(b) Competitive inhibition
Competitive inhibitor
(c) Noncompetitive inhibition
Noncompetitive inhibitor


No inhibitor
Vmax
Vi
Competitive inhibition
Vmax
1/2 Vmax
Noncompetitive inhibition
1/2 Vmax
Km
Km
[S]

Regulation of enzyme activity helps control metabolism

- Chemical chaos would result if a cell’s metabolic pathways were not tightly regulated
- A cell does this by switching on or off the genes that encode specific enzymes or by regulating the activity of enzymes

Allosteric Regulation of Enzymes

- **Allosteric regulation** may either inhibit or stimulate an enzyme’s activity
- Allosteric regulation occurs when a regulatory molecule binds to a protein at one site and affects the protein’s function at another site

Allosteric Activation and Inhibition

- Most allosterically regulated enzymes are made from polypeptide subunits (Quaternary Structure)
- Each enzyme has active and inactive forms
- The binding of an **activator** stabilizes the active form of the enzyme
- The binding of an **inhibitor** stabilizes the inactive form of the enzyme

Figure 8.19a

(a) Allosteric activators and inhibitors

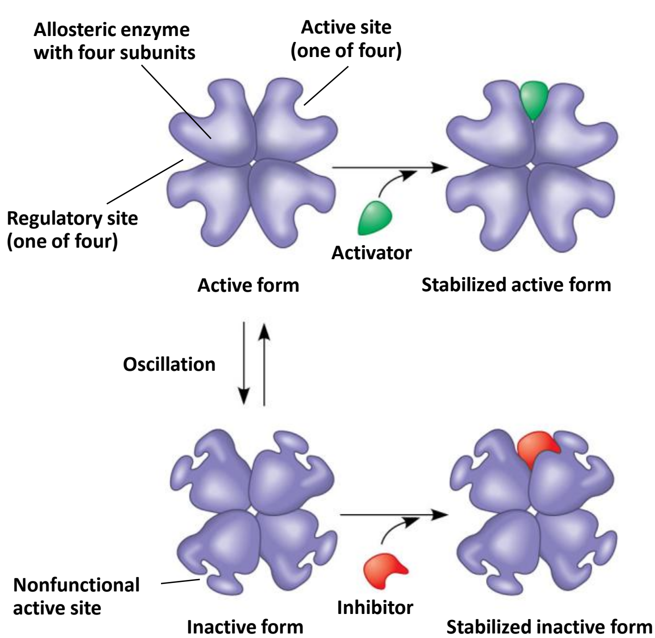
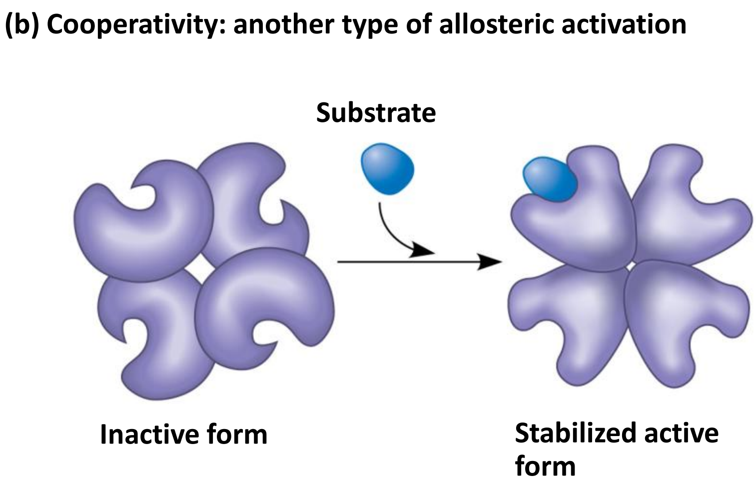


Figure 8.19b



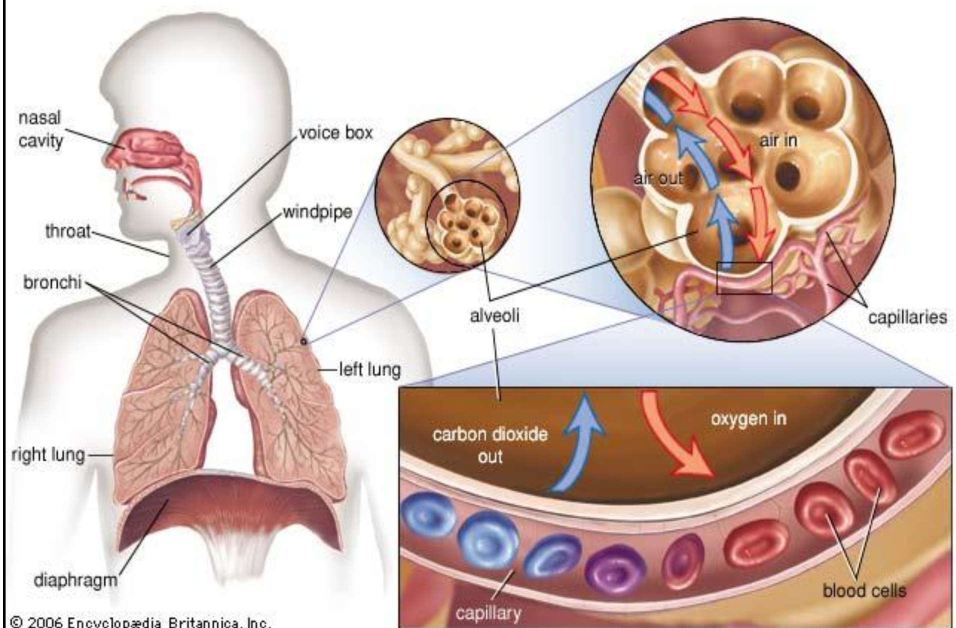
- **Cooperativity** is a form of allosteric regulation that can amplify enzyme activity
- One substrate molecule primes an enzyme to act on additional substrate molecules more readily
- Cooperativity is allosteric because binding by a substrate to one active site affects catalysis in a different active site

Cellular Cooperativity

- Cooperation among cell parts contributes to a cell's specialty
  - Nerve cells
    - Numerous Ion channels in membrane
    - Mitochondria for ATP
    - Vesicles with neurotransmitters
  - White Blood Cells
    - Lysosomes for pathogen digestion
    - Golgi to produce lysosomes
    - Specialized membrane receptors

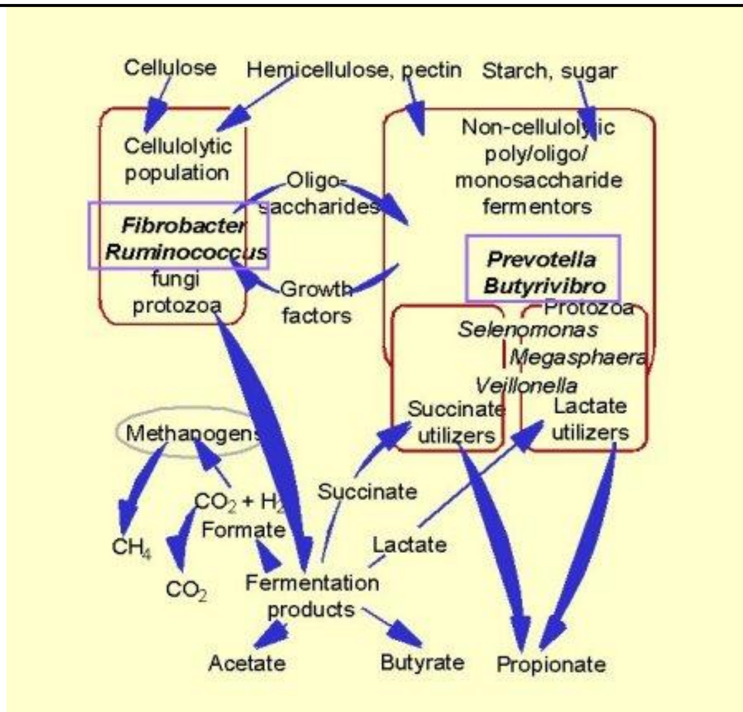
Organ System Cooperativity

- Gas exchange
  - Alveoli in lungs
  - Capillaries for O_2/CO_2 exchange



Unicellular Cooperation

- Microbial communities each produce certain compounds.
- Their individual efforts benefit the community (and host organism in the case of mutualistic bacteria).
- Cow Rumen Microorganism Community



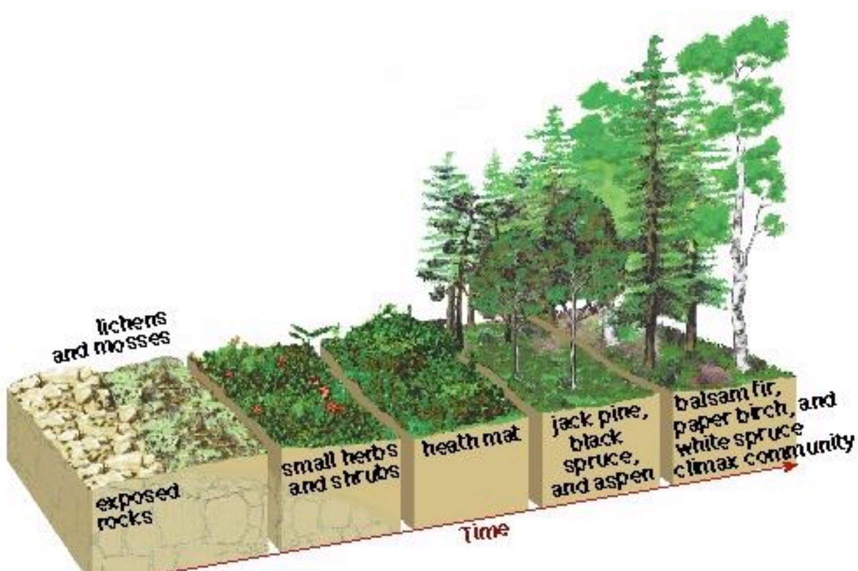
Community Interactions

- How Organisms affect each other
- Analyzed by positive/negative outcomes

Community Interactions

- The distribution and abundance of populations depends on all the interactions among them.
  - Too many lion prides in an area leads to intense competition.
  - Succession in communities leads some species to be replaced by others.

Explain the succession of events over time…

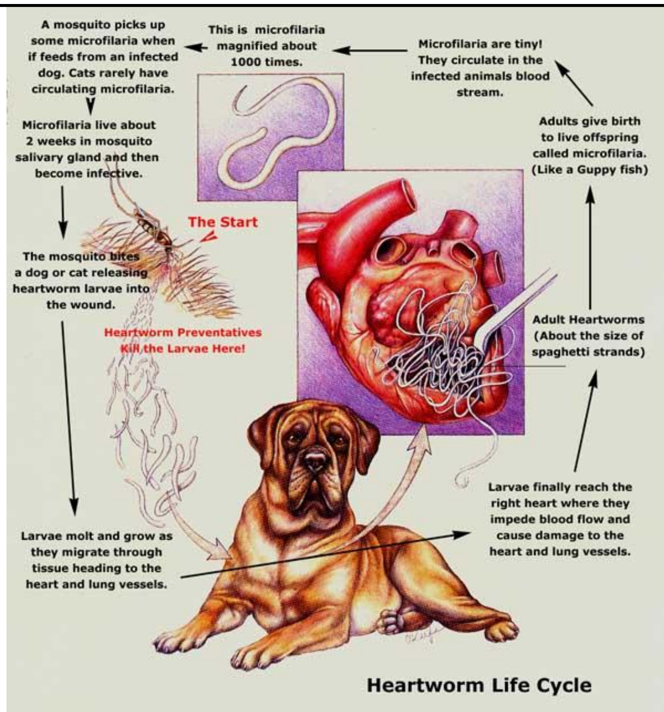


Predation

- Predator eats prey
- Win / Lose

Parasitism

- Parasite lives inside host and harms the host.
  - Eats parts of the host
  - Reproduces inside of the host
- Win / Lose



Herbivory

- An animal eats a plant
- Win / Lose

Competition

- One organism fights another organism for food, land, water.
- Win / Lose OR Lose/Lose

Mutualism

- 2 organisms benefit from each other

Bee gets food
Plant transfers pollen

Win / Win Usually
BUT possibly
Lose/Lose…EXPLAIN!!!

Mimicry

- One organism looks like another

Mimicry

- Batesian Mimicry
  - One **harmless** organism mimics appearance of a harmful organism
- Mullerian Mimicry
  - 2+ species have evolved (independently) similar appearances that both confer harm

Evaluation

- Evaluate the 2 forms of mimicry by answering the following:
  – Which is beneficial to both species and why?
  – Which can be beneficial to one species and harmful to the other? Why?
  – Use authentic examples to justify your responses.

Loss of Species

1. Invasive species
   – Outcompete native species
   – Introduced by humans either accidentally or on purpose

   Kudzu: Introduced from Japan to Philadelphia
   – Spreading 150,000 acres each year!
   – Shades trees/shrubs
   – No natural "predators" to limit growth

Loss of Species

2. Habitat Disturbance/Destruction
   - Forest Logging
   - Gold Mining
   - Construction
   - Military Actions
   - Oil Drilling

Loss of Species

3. Climate Change

- Global Warming & Polar Bears

Ecosystem Distribution

- Continuously changing due to geological & meteorological events.
  - Dinosaurs
  - Continental Drift
  - Desertification